ERDC/EL TR-01-29

US Army Corps of Engineers®
Engineer Research and Development Center

20020305 179

Wetlands Research Program

Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks

Chapter 3
Developing a Reference Wetland System

R. Daniel Smith

September 2001

Environmental Laboratory

Contents

Preface

This chapter in the Guidelines for Developing Regional Guidebooks was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Characterization and Restoration of Wetlands Research Program (CRWRP), Work Unit 32985, "Technical Development of HGM." Mr. Dave Mathis was the CRWRP Coordinator at the Directorate of Research and Development, HQUSACE; Ms. Colleen Charles, HQUSACE, served as the CRWRP Technical Monitor's Representative; and Dr. Russell F. Theriot, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC), was the CRWRP Program Manager.

This report was prepared by Mr. R. Daniel Smith of the Wetlands Branch, Ecological Research Division, EL. This work took place under the general supervision of Dr. Morris Mauney, Chief, Wetlands Branch; Dr. Conrad Kirby, former Chief, Environmental Resources Division; and Dr. John W. Keeley, former Director, EL. Dr. Edwin Theriot is Acting Director, EL.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

This report should be cited as follows:

> Smith, R. D. (2001). "Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks; Chapter 3, Developing a reference wetland system," ERDC/EL TR-01-29, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

3 Developing a Reference Wetland System

Objectives and Assumptions

The objective of this chapter is to provide guidelines for developing a set of reference wetlands to represent a regional wetland subclass. It is assumed that the Assessment Team (A-Team) has defined and characterized a regional wetland subclass according to the guidance outlined in Chapter 2 and developed conceptual assessment models as outlined in Chapter 4. Many of the problems that occur in the development of a Regional Guidebook are rooted in a poorly defined or characterized regional wetland subclass. Similarly, the urge to get to the field and begin sampling reference wetlands before the conceptual model is developed will often result in having to revisit sites later to resample or collect additional information on revised or new model variables. The importance of taking the time that is necessary to develop a clearly defined and well-characterized regional wetland subclass as well as clearly defined functions, variables, and assessment models cannot be overemphasized. Such an approach will increase the likelihood that the Regional Guidebook can be accomplished efficiently with minimal downtime and frustration.

Throughout this chapter the term disturbance is used to refer to changes resulting from natural processes, while terms such as altered, managed, manipulated, or impacted are used to refer to changes resulting from the activities of man. No value judgment is inherent in these terms, simply the recognition that natural processes and anthropogenic activities often affect wetland functions differently. In some situations, however, the activities of man may mimic, to some degree, natural processes in terms of their effect on wetland function. For example, clear-cutting of forests may in some ways resemble the large-scale tree uprooting and snapping caused by the high winds associated with tornadoes or hurricanes. Similarly, the backwater flooding that sometimes occurs behind man-made levees may closely resemble the depth, frequency, and duration of flooding that occurred on a large river prior to the installation of levees or other structures.[1]

---

[1] Personal Communication, 1999, Larry E. Banks, U.S. Army Engineer Division, Mississippi Valley, Vicksburg, MS.

Reference Wetland Terms and Definitions

Reference wetlands

Reference wetlands are the group of wetlands selected from a specified geographic area to represent the entire range of variability exhibited by a regional wetland subclass (Table 3-1). Reference wetlands include the variability that occurs as a result of both natural processes and cycles (e.g., succession, high winds, fire, erosion, and channel migration) as well as anthropogenic causes (e.g., clear-cutting, high grading, grazing, urban development, channelization, dredging, snagging, and levee building).

Table 3-1
Reference Wetland Terms and Definitions

Term	Definition
Reference wetlands	A group of wetlands that encompasses the range of variability exhibited by a regional wetland subclass as a result of both natural processes such as disturbance and anthropogenic alteration.
Reference domain	The geographic area from which reference wetlands representing the regional subclass are surveyed and selected.
Reference standard wetlands	The subset of reference wetlands from a regional wetland subclass that is used to establish the standard of comparison for assessment model variables and functional indices because they sustain the highest level of function across the suite of functions. Generally, they are the least altered wetland sites in the least altered landscapes. By definition, the functional capacity index for all functions in reference standard wetlands is assigned a 1.0.
Reference standard condition	The condition, or range of conditions, exhibited by the measure of a model variable in reference standard wetlands. By definition, a subindex of 1.0 is assigned to the reference standard condition.

Reference domain

Smith et al. (1995) defined the reference domain as the geographic area from which reference wetlands are selected (Table 3-1). In defining the reference domain, the objective is to identify a geographic area that is relatively homogeneous in terms of the factors that influence how wetlands function in the regional subclass.

There are two possible approaches for defining the reference domain. The first is a top-down approach in which one of the existing land (U.S. Department of Agriculture 1981), geomorphic (Saucier 1995), physiographic (Fenneman 1946), climatic (Trewartha 1943), hydrologic (U.S. Geological Survey (USGS) 1982), vegetation (Küchler 1964, 1970), or ecological (Omernik and Gallant 1987, 1988; Omernik 1987; Bailey 1976) classifications is adopted as the basis for defining the geographic extent of regional wetland subclasses. Omernik (1994), Omernik and Gallant (1990), and Gallant et al. (1989) provide

compelling arguments for using ecoregions as the basis for defining an initial reference domain. On the down side, the top-down approach is time- and resource-intensive because it requires a survey of the entire classification unit that is initially selected to ensure that the level of variability that exists in the classification unit does not require the definition of additional regional wetland subclasses (see Chapter 2) or the recalibration of the model variables and functional indices.

The second approach is a bottom-up one in which a small core geographic area is first identified (e.g., a county or watershed) based on initial objectives or responsibilities and then expanded over time as additional reference wetland data are acquired. The expansion continues until the variability encountered requires definition of a new regional wetland subclass or recalibration of the model variables and functional indices. When the bottom-up approach is used, the reference domain may not initially include the entire potential geographic extent of a regional subclass (Figure 3-1). Theoretically, the reference domain for a regional wetland subclass will end up being the same regardless of whether a top-down or bottom-up approach is used to define it.

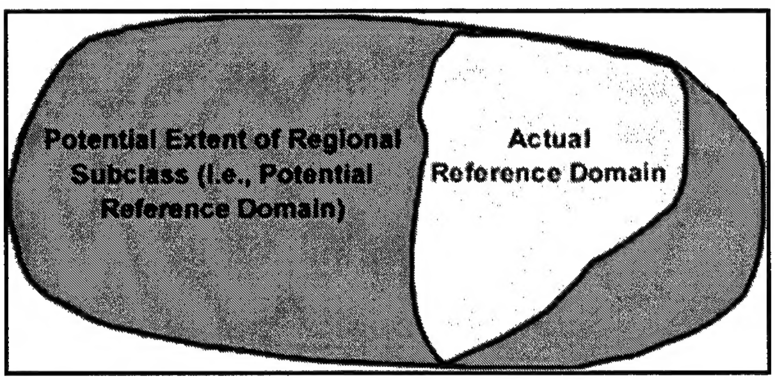

Figure 3-1. Actual versus potential reference domain

Reference standard wetlands and conditions

Reference standard wetlands are the subset of reference wetlands used to establish the standard of comparison for calibrating assessment model variables and functional indices (see Chapter 4). In the Hydrogeomorphic (HGM) Approach, the least altered wetlands in the least altered landscapes are selected as reference standard wetlands. This is based on the assumption that these wetlands sustain the highest level of functioning across the suite of functions that are inherent to the regional wetland subclass. Using "least altered" as the criterion for reference standard wetlands ensures compliance with the mandate of the Clean Water Act to maintain the physical, chemical, and biological integrity of wetlands and waters of the United States through the execution of the 404 Regulatory Program, and the national policy prescribing a "no net loss" of wetland function (Executive Order 11990, Protection of Wetlands).

By definition, the condition or range of conditions exhibiting the measure of model variables in reference standard wetlands is assigned a subindex of 1.0 based on a scale of 0.0 to 1.0. Similarly, by definition, the Functional Capacity Index for all functions in reference standard wetlands is assigned a 1.0 based on a scale from 0.0 to 1.0 (see Chapter 4).

Purpose of Reference Wetlands

Reference ecosystems, while unique to the HGM Approach in the arena of wetland assessment, are an integral component in a variety of other assessment methods. For example, they have been used in the assessment of forests (U.S. Forest Service 1984), range (U. S. Soil Conservation Service 1981), streams and lakes (Hughes, Larsen, and Omernik 1986; Hughes et al. 1993), and watersheds (Biggs et al. 1990; Warrey and Hanau 1993).

Reference wetlands serve several purposes in the Hydrogeomorphic Approach. First, reference wetlands function as the physical representation of wetlands from the regional that can be observed and measured repeatedly. Second, reference wetlands make it possible to establish the range of variability exhibited by the measures of model variables. This information makes it possible to calibrate model variables and functional indices. Third, reference wetlands serve as a template for wetland restoration by providing design specifications (i.e., reference standard conditions).

Selecting Reference Wetland Sites

Selection strategies

The first step in selecting reference wetland sites is to conduct an inventory of wetland sites belonging to the regional wetland subclass in the reference domain. This inventory should draw from a variety of sources including A-Team members, individuals with broad knowledge of wetlands in the region, Natural Area Inventories, wetland regulatory permit files, U.S. Environmental Protection Agency (EPA) Advanced Identification Studies, Special Area Management Plans, public lands, National Wetland Inventory, State and local wetland maps, as well as many other potential sources of information.

Once the inventory is complete, the next step is to begin to conduct field reconnaissance to screen potential candidate reference wetland sites. The objective is to identify sites that represent the range of conditions that exist in the reference domain from highly altered sites in highly altered landscapes to unaltered sites in unaltered landscapes. It is also important in the context of unaltered sites to select a range of sites that reflect the various types of natural disturbances and cycles that occur in the reference domain. A form similar to the one shown in Table 3-2 will help to ensure that all the appropriate information is collected and organized efficiently. Displaying reference wetland

Table 3-2 Reference Wetland Summary Sheet	
Site name	Possum Creek Slough
Site number / code	RB-123
Site location description	5 miles past the Jitney Jungle on Highway 61
USGS 7.5-minute quad	Sharkey
County soil survey	Sharkey - Sheet #6
Township / section / range	Township 7W, Range 6N, NW 1/4, of NW 1/4, of Section 5
UTM coordinates	100798 3457586
HGM class	Riverine
Local point of contact	Bubba Jones (caretaker) 601-987-3456
Regional subclass	Local point of contact
Environment of deposition	Historical backswamp of the Mississippi River
Condition class (1-5, 1=RS)	1 - Primo reference standard site as good as it gets
Type of alteration	No hydrologic or land surface alterations
Site description	This site supports a mature stand of Quercus lyrata. It has...

locations on a 1:100,000-scale map will help to stratify the placement of reference wetlands throughout the reference domain.

Number of reference wetland sites

A variety of factors will influence how many reference wetlands should be included in the reference wetland system. The first factor is, of course, the size and heterogeneity of the reference domain. Large reference domains will require more reference wetland sites to ensure adequate representation. Reference domains with a wide variety of alteration scenarios will require more reference wetland sites than reference domains where one or a few alteration scenarios exist. Another factor is the level of resolution necessary to detect the types of impacts that typically affect wetlands in the regional subclass. Finally, as in all projects, the ideal number of reference wetland sites dictated by the foregoing considerations must be balanced against the realities of budgets, time, and personnel.

A relatively simple way to determine when an adequate number of reference wetland sites has been sampled is to plot a measure of variability (e.g., variance or standard deviation) of variable measures as the data from reference wetland sites is acquired (Figure 3-2). This approach is similar to the species area curve (Arrhenius 1921; Cain 1938; and Condit et al. 1996). Statistical methods for determining what constitutes an adequate number of reference sites have been

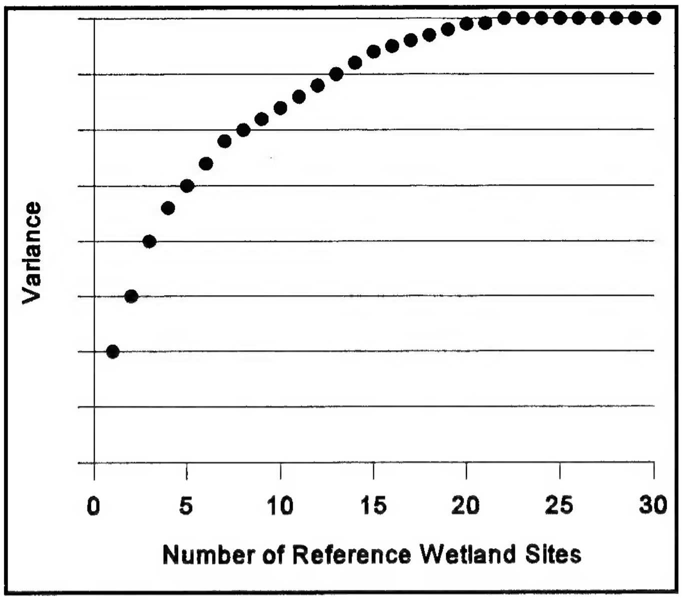

Figure 3-2. Trend in variance for a model variable measure

explored by Hughes et al. (1992), Loftis et al. (1989), Walters, Collie, and Webb (1988), and Green (1979).

Designating Reference Standard Wetlands

Which reference wetlands are designated as reference standard wetlands has far reaching ramifications in the HGM Approach. Hughes (1994) identified a set of criteria for defining reference conditions in rivers and streams in the context of Index of Biological Integrity. These criteria are also appropriate to consider in designating reference standard wetlands. Adapting these criteria reference standard wetlands

- Must be politically palatable and reasonable.
- Must include a large number of sites from the regional subclass.
- Must represent important aspects of prehistory or pre-Columbian conditions.
- May use minimal disturbance as the surrogate for prehistorical conditions given the difficulty of establishing prehistorical conditions.
- Must be uniform across political boundaries and bureaucracies (e.g., Federal, State, local).

As indicated in Chapter 3, in the HGM Approach reference wetlands that are the least altered wetlands in the least altered landscapes are selected as reference standard wetlands. This is based on the ecosystem focus of the HGM Approach and the assumption that these wetlands sustain the highest level of functioning across the suite of functions that are inherent to the regional wetland subclass. Several studies have outlined the use of this approach to designating reference standard wetlands (Brinson and Rheinhardt 1996; Rheinhardt, Brinson, and Farley 1997).

Some have argued (Hruby 1997) that the "least altered system" criterion for establishing the standard of comparison is inappropriate because it penalizes altered or managed wetlands where the level of a particular function is significantly greater than the level exhibited by reference standard wetlands as defined by the HGM Approach. It is certainly possible for wetlands to be altered such that the level at which individual functions are performed is less than or greater than the sustainable levels observed in unaltered reference standard wetlands. Direct manipulation of wetland characteristics and processes to enhance specific functions is common practice in the area of wildlife and water resources management (King 1996; Haukos and Smith 1993; Payne 1992; Chescheir et al. 1991; Landers 1991; Feeney and Morrell 1985; Fritz and Helle 1979; Kadlec and Tilton 1979; Bender and Correll 1974). In many other cases, however, the deflection from reference standard levels of function is not a result of wetland management activities per se, but rather the result of unregulated or exempt activities that are perceived to be either unrelated or insignificant. Activities such as land use change, forestry practices, and channel modification may fall into these categories.

In order to account for the functions performed by highly altered systems, an alternative "function-by-function" approach has been proposed for establishing the standard of comparison for calibrating assessment model variables and functional indices. Under this approach, the wetlands in the regional subclass that perform Function 1 at the highest level would be selected as the reference standard wetland group for Function 1. Another, perhaps different group of wetlands, that perform Function 2 at the highest level would be selected as the reference standard wetland group for Function 2. Membership in the reference standard wetland group used to establish the standard of comparison for calibrating model variables and functional indices would be based solely on the ability of the wetland to perform a particular function. The ability of the wetland to perform the remaining suite of functions would not be considered.

There are several problems with the function-by-function approach aside from the obvious bookkeeping confusion that could result. First, the approach ignores the fact that wetlands are complex, integrated systems that simply cannot be assessed function by function with meaningful results. Second, the approach fails to comply with the fundamental directive of the Clean Water Act to "maintain the physical, chemical, and biological integrity" of wetlands and waters of the United States. Third, the approach makes it impossible to provide a set of design criteria for restoring wetlands. It is a synthetic abstraction concocted from components of many different "real" wetlands. However, no

such wetland actually exists, nor could such a wetland be created or restored because it is not possible to combine the physical, chemical, and biological characteristics and processes of the different reference standard wetlands in the same physical space.

Use of Historical Information to Reconstruct Reference Standard Wetlands

When the wetlands in the reference domain of a regional wetland subclass have experienced extensive alteration, it may be possible to reconstruct a reference standard wetland using historical accounts and photography. Several examples of this approach are available in the literature for reconstructing historical conditions in lakes, streams, and coastal wetlands (Baker et al. 1993; Hughes and Noss 1992; Lyon and Green 1992; Sedell and Frogatt 1984; Sedell and Luchessa 1981; and Trautman 1981).

References

Arrhenius, O. (1921). "Species and area," *Journal of Ecology* 9, 95-99.

Bailey, R. G. (1976). "Ecoregions of the United States map (scale 1:7,500,000)," U.S. Department of Agriculture, Forest Service, Intermountain Region, Ogden, UT.

Baker, J. P., Warren-Hicks, W. J., Gallagher, J., and Christensen, S. W. (1993). "Fish population losses from Adirondack lakes: The role of surface water acidity and acidification," *Water Resources Research* 29, 861-874.

Bender, M. E., and Correll, D. L. (1974). "The use of wetlands as nutrient removal systems," Publication No. 29, Chesapeake Research Consortium, Baltimore, MD.

Biggs, B. J. F., Duncan, M. J., Jowett, I. G., Quinn, J. M., Hickey, C. W., Davies-Colley, R. J., and Close, M. E. (1990). "Ecological characterization, classification, and modelling of New Zealand rivers: An introduction and synthesis," *New Zealand Journal of Marine and Freshwater Research* 24, 277-304.

Brinson, M. M., and Rheinhardt, R. (1996). "The role of reference wetlands in functional assessment and mitigation," *Ecological Applications* 6, 69-76.

Cain, S. A. (1938). "The species area curve," *American Midland Naturalist* 19, 573-81.

Chescheir, G. M., Gilliam, J. W., Skaggs, R. W., and Broadhead, R. G. (1991). "Nutrient and sediment removal in forested wetlands receiving pumped agricultural drainage water," *Wetlands* 11(1), 87-103.

Condit, R., Hubbell, S. P., Lafrankie, J. V., Sukumar, R., Manokaran, N., Foster, R. B., and Ashton, P. S. (1996). "Species-area and species-individual relationships for tropical trees: A comparison of three 50-ha plots," *Journal of Ecology* 84(4), 549-62.

Feeney, P., and Morrell, B. (1985). "Wetlands disposal is sewage option," *American City and County* 100, 91-92.

Fenneman, N. M. (1946). "Physical divisions of the United States map (scale 1:7,000,000)," U.S. Geological Survey, Reston, VA.

Fritz, W. R., and Helle, S. C. (1979). "Cypress wetlands - natural tertiary treatment alternative," *Water and Sewage Works* 126(4), 58-60.

Gallant, A. L., Whittier, T. R., Larsen, D. P., Omernik, J. M., and Hughes, R. M. (1989). "Regionalization as a tool for managing environmental resources," EPA-600-3-89-060, U.S. Environmental Protection Agency, Office of Research and Development, Corvallis, OR.

Green, R. H. (1979). *Sample design and statistical methods for environmental biologists.* Wiley-Interscience, New York.

Haukos, D. A., and Smith, L. M. (1993). "Moist-soil management of playa lakes for migrating and wintering ducks," *Wildlife Society Bulletin* 21(3), 288-98.

Hruby, T. (1997). "Continuing the discussion: Scientific and technical issues regarding the Hydrogeomorphic Approach to function assessment of wetlands," *Society of Wetland Scientists Bulletin* 14, 23-24.

Hughes, R. M. (1994). "Defining acceptable biological status for comparing with reference condition." *Biological assessment and criteria: Tools for water resource planning and decision making.* W. S. Davis and T. P. Simon, ed., Lewis Publishers. Boca Raton, FL, 31-48.

Hughes, R. M., and Noss, R. F. (1992). "Biological diversity and biological integrity: Current concerns for lakes and streams," *Fisheries* 17, 11-19.

Hughes, R. M. , Larsen, D. P., and Omernik, J. M. (1986). "Regional reference sites: A method for assessing stream potential," *Environmental Management* 10, 629-635.

Hughes, R. M., Johnson, C. B., Dixit, S. S., Herlihy, A. T., Kaufmann, P. R., Kinney, W. L., Larsen, D. P., Lewis, P. A., McMullen, O. M., Moors, A. K., O'Connor, R. J., Paulsen, S. G., Stemerger, R. S., Thiele, S. A., Whittier T. R., and Kugler, D. L. (1993). "Development of lake condition indicators for EMAP - 1991 Pilot." *EMAP - Surface waters 1991 pilot report.* EPA-620-R-93-003, D. P. Larsen and S. J. Christie, ed., U. S. Environmental Protection Agency, Office of Research and Development, Corvallis, OR, 7-90.

Hughes, R. M., Whittier, T. R., Thiele, S. A., Pollard, J. E., Peck, D. V., Paulson, S. G., McMullen, D., Lazorchak, J., Larsen, D. P., Kinney, W. L., Kaufman, P. R., Hedtke, S., Dixit, S. S., Collins, G. B., and Baker, J. R. (1992). "Lake and stream indicators for the United States Environmental Protection Agency's environmental monitoring and assessment programs." *Ecological Indicators.* D. H. McKenzie, D. E. Hyatt, and V. J. McDonale, ed., Elsevier Applied Science, New York, Vol 1, 305-335.

Kadlec, R. H., and Tilton, D. L. (1979). "Use of freshwater wetlands as a tertiary wastewater-treatment alternative," *CRC Critical Reviews in Environmental Control* 9, 185-212.

King, S. L., and Allen, J. A. (1996). "Plant succession and greentree reservoir management: Implications for management and restoration of bottomland hardwood wetlands," *Wetlands* 16, 503-511.

Küchler, A. W. (1964). "Potential natural vegetation of the conterminous United States," Special Publication No. 36, American Geographical Society, A. Hoen, Baltimore, MD.

__________. (1970). "Potential natural vegetation map (scale 1:7,500.000)." *The national atlas of the United States of America.* U.S. Geological Survey, Washington, DC, Plates 90 and 91.

Landers, J. (1991). "Use of wetlands for water quality improvement under the U.S. Environmental Protection Agency; Region V Clean Lakes Program," *Environmental Management* 15, 151-62.

Loftis, J. C., Ward, R. C., Phillips, D., and Taylor, C. H. (1989). "An evaluation of trend detection techniques for use in water quality monitoring program," EPA-600-3-89-037, U.S. Environmental Protection Agency, Office of Research and Development, Corvallis, OR.

Lyon, J. G., and Greene, R. G. (1992). "Use of aerial photographs to measure the historical areal extent of Lake Erie Coastal Wetlands," *Photogrammatic Engineering and Remote Sensing* 58(9), 1355-60.

Omernik, J. M. (1987). "Ecoregions of the conterminous United States," *Annals of the Association of American Geographers* 77, 118-125.

Omernik, J. M. (1994). "Ecoregions: A spatial framework for environmental management." *Biological assessment and criteria: Tools for water resource planning and decision making.* W. S. Davis and Simon, T. P. ed., Lewis Publishers, Boca Raton, FL, 49-62.

Omernik, J. M., and Gallant, A. L. (1987). "Ecoregions of the upper midwest states," EPA-600-D-87-315, U.S. Environmental Protection Agency, Office of Research and Development, Corvallis, OR.

Omernik, J. M., and Gallant, A. L. (1988). "Ecoregions of the south central states," EPA-600-3-88-037, U.S. Environmental Protection Agency, Office of Research and Development, Corvallis, OR.

__________. (1990). "Defining regions for evaluating environmental resources." *Global natural resource monitoring and assessments: Preparing for the 21st century.* H. G. Lund and G. Reto, coordinators, American Society of Photogrammetry and Remote Sensing, Bethesda, MD, 936-947.

Payne, N. F. (1992). *Wildlife habitat management of wetlands.* McGraw-Hill, New York.

Rheinhardt, R., Brinson, M. M., and Farley, P. M. (1997). "Applying wetland reference data to functional assessment, mitigation, and restoration," *Wetlands* 17, 195-215.

Saucier, R. (1995). "Quaternary deposits of the lower Mississippi River Valley," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sedell, J. R., and Frogatt, J. L. (1984). "Importance of streamside forests to large rivers: The isolation of the Willamette River, Oregon, USA, from its floodplain by snagging and streamside forest removal," *Internationale Vereinigung für Theoretische und Angewandte Lumnologie Verhandlungen* 22, 1828-1834.

Sedell, J. R., and Luchessa, K. J. (1981). "Using the historical record as an aid to salmonid habitat enhancement." *Acquisition and utilization of aquatic habitat inventory information.* American Fisheries Society Symposium Proceedings, Portland, OR, N. B. Armentrout, ed., October 28-30, 1981.

Trautman, M. B. (1981). *The fishes of Ohio.* 2nd ed., Ohio State University Press, Columbus, OH.

Trewartha, G. T. (1943). *An introduction to weather and climate.* 2nd ed., McGraw-Hill, New York.

U. S. Department of Agriculture. (1981). "Land resource regions and major land resource areas of the United States," Agricultural Handbook 296, U.S. Government Printing Office, Washington, DC.

U. S. Forest Service. (1984). "Field instructions for southern New England," U.S. Forest Service, Radnor, PA.

U.S. Geological Survey. (1982). "Hydrologic unit map of the United States, map scale (1:7,500,000)," U.S. Government Printing Office, Washington, DC.

U.S. Soil Conservation Service. (1981). "National range handbook," U.S. Department of Agriculture, Washington, DC.

Walters, C. J., Collie, J. S., and Webb, T. (1988). "Experimental design for estimating transient responses to management disturbances," *Canadian Journal of Fisheries and Aquatic Sciences* 45, 530-538.

Warrey, W. D., and Hanau, M. (1993). "The use of terrestrial ecoregions as a regional scale screen for selecting representative reference sites for water quality monitoring," *Environmental Management* 17, 267-276.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
September 2001	Final report	

4. TITLE AND SUBTITLE
Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks
Chapter 3: Developing a Reference Wetland System

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

R. Daniel Smith

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
32985

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/EL TR-01-29

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

In the Hydrogeomorphic (HGM) Approach, reference wetlands are the group of wetlands selected from a specific geographic area to represent the entire range of variability exhibited by a regional wetland class. Reference standard wetlands are the subset of reference wetlands used to establish the standard or comparison for calibrating assessment model variables and functional indices under the HGM Approach. This chapter provides guidelines for selecting a set of reference wetlands to represent a regional wetland subclass. It begins with the definition of terms, and continues with discussions on the purpose of reference wetlands, selection strategies, number of reference wetland sites, designation of reference wetland standard sites, and use of historical information in reconstructing reference standard wetlands.

15. SUBJECT TERMS

Assessment models	HGM	Hydrogeomorphic classification	Reference wetlands	Wetland assessment
Functional assessment	Hydrogeomorphic approach	Reference standard wetlands	Regional wetland subclasses	Wetland functions

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		17	